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DEVELOPMENT OF A PROTOTYPE EXPERIMENTAL PLAN TO EVALUATE STABILIZED OPTICAL VIEWING DEVICES. II. INFLIGHT MEASURES OF AIRSICKNESS POTENTIAL.

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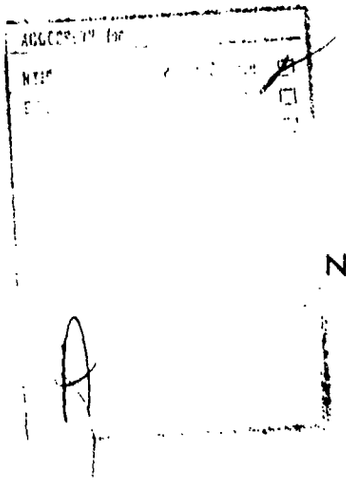

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SUMMARY PAGE

THE PROBLEM

There is considerable multiservice interest in hand-held optical viewing devices that utilize internal stabilization mechanisms to minimize optical motion of a sighted image brought about by inertial motion or vibration of the observation vehicle. Although the stabilization feature of these devices offers various degrees of improvement in air-to-ground observation tasks, a number of field evaluation studies have indicated the occasional incidence of disorientation, vertigo, and nausea side effects in persons sighting through the device optics. This manifestation of motion sickness-like symptoms has, in general, been attributed to the stabilization feature proper of the viewing devices. The present study was implemented in support of a joint Army/Navy effort to develop a prototype experimental plan to evaluate the effects of such stabilized devices on observer performance.

FINDINGS

Investigators at the Naval Aerospace Medical Research Laboratory and the U. S. Army Aeromedical Research Laboratory conducted a combined field and laboratory study to evaluate observer performance while using an improved XM-76 stabilized viewing device. Air-to-ground observations were made in a UH-1 aircraft, flying maneuvers modeled in part after a scout helicopter scenario. The experimental protocol was such that visual acuity data were collected under three different observation conditions: with the naked eye, with XM-76 operated in its normal stabilized mode, and with the XM-76 operated in a caged or nonstabilized mode. Measures of selected airsickness symptoms were derived from an onboard flight observer and from postflight questionnaires. The resulting data indicate that the level of airsickness symptoms manifested by the subject group while using the device was higher than the baseline level present when the observations were made without the device. This rise in symptom level was found to be present whether the XM-76 optics were stabilized or nonstabilized. Importantly, no statistically significant difference could be found between the magnitude of the symptoms present when the device was stabilized and the magnitude when caged. In contradistinction to the hypothesis that the stabilization feature of such devices increases the airsickness potential, the general trend of the data showed the opposite effect. A previous report detailed the results of the visual acuity aspects of the project. The present report pertains primarily to the inflight measures of airsickness potential. A third report will describe the results of the laboratory evaluation of airsickness susceptibility of the individual subjects.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

INTRODUCTION

Over the past several years there has been considerable multiservice interest in the development, test, and evaluation of hand-held optical viewing devices (refs. 1-15) that feature internal stabilization mechanisms designed to minimize optical motion of the sighted image brought about by inertial motion or vibration of the observation vehicle. With conventional nonstabilized binoculars, vehicle motions produce considerable angular deviations of the central optical axis of the device about the selected line-of-sight target axis, resulting in degraded visual acuity. Although the new viewing devices utilize a variety of different hardware approaches to the stabilization problem (refs. 1,2), they possess, in general, the common feature of inertially stabilizing one or more optical elements over some fixed low-frequency operating range. As a result of this stabilization, the devices present a relatively fixed image referred to the viewer's eye, even though the external case or configuration is subjected to vibration or tremor brought about by motions of the vehicle-observer combination. Typical applications which stand to benefit from the resulting improvement in visual performance include search and rescue missions as well as all forms of forward air observation, ranging from artillery and air-strike evaluation through troop movement surveillance.

Though these devices offer significant operational advantages from the visual acuity standpoint, various sources (refs. 8-15) have either reported or discussed the occasional incidence of side effects, such as disorientation, vertigo, dizziness, headache, and certain motion sickness symptoms including nausea in observers using a stabilized type of viewing system. The related studies and field evaluations, although not directed toward determining the causes of these side effects, attributed the problem, in general, to the stabilization feature proper. Importantly, the wide range of symptoms reported in these studies points toward involvement of the vestibular system. Specifically, the majority of the reported symptoms fall into the two distinct response categories utilized by Graybiel (ref. 16) to formally structure motion sickness symptomatology. The disorientation, vertigo, and dizziness responses represent the effects of stimulation of the vestibular system, which he termed as V-I manifestations. The nausea and related motion sickness symptoms reported when using the stabilization device represent the interaction or crossover effect of the stimulated vestibular system on other mechanisms which Graybiel described as V-II manifestations.

As reviewed by Money (ref. 17), it has been well established that stimulus situations that result in the production of different motion information by the visual and vestibular sensory systems can effect a full range of motion sickness-like symptoms. Representative interpretations of the effect of these sensory motion contradictions include the sensory conflict theory of Steele (ref. 18) and the neural mismatch hypothesis of Reason (ref. 19). In the case of stabilized viewing devices, the potential for conflicts in the information provided by the visual and vestibular systems definitely exists. For example, when distant targets in a moving environment are viewed, the oculovestibular control system operates in such a fashion as to provide a reasonable degree of inertial stabilization of the line-of-sight of the eyes over a limited frequency spectrum

(ref. 20). In effect, angular oscillations of the head that are produced by vehicular motion are sensed by the vestibular system, which in turn delivers biocontrol signals to the oculomotor system that effect eye motions in the counterdirection of the head motions. When a viewing device with stabilized optics is utilized in conjunction with this internal stabilization system, the potential for phase and amplitude interactions is quite feasible as outlined by Cramer (ref. 10). Further complications that might contribute to the motion sickness problem could include the magnification feature, optical distortion, limited peripheral vision, or the effect of using any optical device, stabilized or nonstabilized, for a prolonged period of time in a motion environment.

As outlined in a related joint Army/Navy project report (ref. 21), the U. S. Army Aeromedical Research Laboratory (USAARL) was requested (ref. 22) to investigate the vertigo and airsickness potential of stabilized optical viewing devices in relation to their planned usage in the product-improved scout helicopter program. The Naval Aerospace Medical Research Laboratory (NAMRL) was also asked for medical advice (ref. 23) on a reported nausea problem during air-to-ground observation by the Marine Corps while operating in Viet Nam. (Since that time, the Marine Corps has issued a "Required Operation Capability" [ref. 24] for the development of a small hand-held image stabilization device.) As a result of this mutual Army/Navy interest in the same operational problem, and because of the complementary facilities and capabilities of USAARL and NAMRL, a joint research program was initiated under the sponsorship of the two laboratories.

The primary objective of this program is to develop a prototype experimental plan or procedure that can be used to evaluate the over-all performance of observers using stabilized viewing devices under representative field conditions. As part of this program, a controlled field study of the use of an XM-76 stabilized viewing device was implemented at the USAARL facility. This study involved the inflight acquisition of subject visual acuity and airsickness symptom level data under different viewing conditions while air-to-ground observations were made from a UH-1 helicopter performing selected maneuvers. The field study was followed by a laboratory study conducted at the NAMRL facility to establish the motion sickness susceptibility of the subject group participating in the field study. A previous report (ref. 21) details the experimental protocol and results of the visual acuity aspects of the field study; the present report details the airsickness aspects of the same study. A third report will summarize the results of the motion sickness susceptibility tests given to the subject group at the NAMRL facility.

EXPERIMENTAL PROCEDURE

Development of design criteria for that initial study was keyed to the exploration of the airsickness potential of only one optical variable--the stabilization feature proper. This decision to study only one variable was based primarily on the fact that air-to-ground observation with any form of conventional viewing device such as 7 X 50 binoculars is most difficult because of aircraft vibration. Since the stabilized optical

devices definitely improve visual performance under these conditions, it would be expected that the amount of time spent by an observer using a stabilized device during a given flight would probably be significantly longer than the time he would spend performing the same task with conventional nonstabilized binoculars. For this reason, it was decided to set up an experimental protocol whereby each observer would make two sets of air-to-ground observations: one set with a stabilized device, the other with a nonstabilized device, with the condition that the total amount of time spent utilizing the two devices be equalized. Since nauseogenic effects of a visual task can be avoided by closing the eyes, it was deemed necessary to develop a systemized inflight visual acuity task that would require the same amount of visual effort for each of the experimental conditions. Similarly, it was desired to obtain an inflight measure of visual performance so as to both identify any acuity improvement afforded by the stabilized device and to describe any performance degradation effects that might result from motion sickness.

Another design criterion involved the desirability of having a standard set of flight maneuvers for the experiment so as to equalize the motion stimuli presented to each observer while performing the visual acuity task. The objective here was to develop a set of maneuvers that would in part be representative of a typical scout helicopter mission, with the condition that the magnitude of force profile of the maneuvers not be of a sufficient level to cause significant motion sickness or disorientation effects in the absence of a visual performance task. Additional criteria included the development of a method for the airborne rating of the airsickness reactions of the subjects while they used the devices, and development of a series of laboratory tests to evaluate the visual and vestibular function and motion sickness susceptibility of the subject group. This latter criterion was based on the desire to ensure that the subject group would represent a normal range of reactivity to motion.

Based on the above criteria, the following experimental protocol was developed. Each participating subject was exposed to three different flights in a UH-1 aircraft. During each flight the subject was assigned a target identification task which was performed while the helicopter flew a series of selected maneuvers. An onboard observer was assigned to monitor and direct the visual performance task as well as to rate selected airsickness symptoms that might arise during the flight. On the first flight, the subject was required to perform the target identification task without the assistance of a viewing device. This flight served an indoctrination function and provided a source of baseline data for airsickness symptoms for each subject. On the second flight, half of the subjects were scheduled to utilize the stabilized device and half, the nonstabilized device. On the third flight, the order was reversed for the two subject groups. Specific methodology and apparatus details follow:

The stabilized optical viewing device used for the experiment was the Model XM-76 (redesignated Model MS-023) manufactured by the Dynasciences Corporation. Although other similar devices would have satisfied the experimental requirements of the study, the XM-76 was selected because of its ready availability and because of its considerable past exposure to various field tests and evaluations. With this monocular

viewing device, optical image stabilization is achieved by a gyroscopically controlled, variable-wedge, fluid prism. Although the device also possesses a zoom capability ranging from 1.5X to 12X, it was used in the 7X mode throughout to prevent confounding zoom effects with the stabilization effects undergoing investigation.

Twenty-nine commissioned officers in the U. S. Army were used as subjects. Two had graduated from the rotary wing flight training program, one had completed 94 hours in the rotary wing program, and the remainder were entering student aviators. All subjects had had previous flight experience either as private pilots or as passengers during Army tactical air operations. Each subject flew one flight on each of three separate, generally consecutive, days. Each flight consisted of five passes at target areas placed at opposite ends of a 9-km instrumented test range (ref. 25) over slightly rolling farm and woodlands. Passes 1 and 5 involved straight and level flight to the same target, Passes 2 and 4 involved a mild "pop-up" maneuver, and Pass 3 consisted of continuous "S" turns with heading changes of 30 to 40 degrees either side of the target line. The average airspeed during each pass was approximately 55 knots; the average altitude was 300 feet, with the pop-up maneuver involving descent to approximately 50 feet.

The subjects' first task on each pass was to locate the target area with the unaided eye before using the XM-76 (except on the first flight when all sighting was with the naked eye). The two target areas, identical in layout, consisted of two white panels upon which were mounted three Landolt C's that could be manually pre-positioned in one of eight possible positions by ground personnel. Target 1 was twice as large as Target 2 which, in turn, was twice as large as Target 3. Utilizing a forced-choice procedure, the subject was repeatedly directed to determine the position of the Target 1 gap as soon as he reported that he could detect the two panels. The criterion for correct response to the Target 1 gap was two successive responses of the correct orientation of the C. The subject was then instructed to concentrate on the next smaller target, and the procedure was repeated. A digital range meter (ref. 25) installed in the aircraft allowed the onboard observer to record target range within 50 meters at the time of each subject response.

Before each flight and after each pass at the target, the same onboard observer who directed the subject visual acuity task evaluated and check-list scored selected airsickness symptoms, including pallor, sweating, facial expression, and inflight anxiety. A second, ground-based observer rated similar postflight symptoms following the flight. The pre/postflight checklist filled out on each flight is shown on Page A-1 of the Appendix. The data sheet used by the onboard observer for each of the five passes is shown on Page A-2. In the main, this subject rating system derives from a Brief Vestibular Disorientation Test (refs. 26,27) which was developed at NAMRL for the evaluation of individual susceptibility to angular Coriolis acceleration stimulation.

Immediately after the second flight, each subject was asked to fill out the debriefing questionnaire shown on Pages A-3 and A-4. This questionnaire concentrated on his relative evaluation of his own reactions during the flight. The same questionnaire was again used after Flight 3. In addition, a comparative questionnaire was issued

postflight, which allowed the subject to compare his Flight 3 reactions to his Flight 2 reactions (Page A-5). On the day following Flight 3, the subject group (generally six subjects) were flown to the NAMRL activity for the follow-up laboratory tests of visual-vestibular function.

A further point related to the experimental protocol concerns the pre-experiment briefing given to each subject. At that time, primary emphasis was placed on the desire of the experimenters to detect any differences in visual acuity that might arise due to optical adjustments on the device. Although the subjects were given preflight practice in using the XM-76 device, they were not told that one flight would involve using the device in the stabilized mode and the other in the caged or nonstabilized mode. In effect, they knew only that some experimental manipulation of the device optics would occur during Flights 2 and 3. During this initial briefing, no mention was made of disorientation or motion sickness. A further point is that the subjects were informed that the onboard observers would record their visual performance during each pass. No mention was made of the concurrent airsickness rating duties of the observer. Only at the end of Flight 2, when they were requested to complete the postflight debriefing questionnaire (Pages A-3 and A-4), did it become obvious to the subject group that the experiment was also concerned with determining their subjective opinion of the motion sickness potential of the device. This procedure was followed in an attempt to reduce the effects of any preflight bias against the device.

RESULTS AND DISCUSSION

A brief statistical summary of the visual acuity scores recorded for the subject group (N = 29) is presented in Table I for each of the flight conditions. These scores represent the mean range in kilometers where the subjects properly identified the orientation of the randomly set Target 1 Landolt C. As noted earlier, the Flight 1 observations were made with the naked eye, while the Flight 2 and 3 observations were made with the assistance of the XM-76 viewing device. On Flight 2, approximately half of the subject group operated the device in its normal stabilized mode, with the remainder operating the device in its caged or nonstabilized mode. On Flight 3, the order was reversed, with each subject group operating the device in the opposite mode.

Inspection of the group mean data in Table I indicates, as would be expected, that the use of the XM-76 device on Flights 2 and 3 resulted in improved visual acuity, as compared to the naked eye observations made on Flight 1. Similarly, the visual acuity data listed under the Caged and Stabilized headings indicate an expected improvement due to device stabilization. These data indicate that the stabilization feature improved target identification by a factor of 1.74 compared to the naked eye observations and by a factor of 1.2 compared to the nonstabilized XM-76 observations. In the t-test summary of differences in group means shown at the bottom in Table I, it can be seen that the improvement in visual acuity afforded by the use of the XM-76, whether stabilized or caged, was statistically significant to the .001 level for both Flights 2 and 3 relative to Flight 1. The improvement in acuity afforded by stabilization was also significant to the .001 level. The larger mean score for the Flight 3 observations as compared

Table I

Summary of inflight visual acuity scores (measured as the range in kilometers where the subject properly identified the orientation of the target (Landolt C) for the 29 subject experimental group based on the individual mean of the 5 passes made at the targets during each of the three flights. Observation was performed with the naked eye on Flight 1 and with the XM-76 viewing device on Flights 2 and 3. On Flight 2, 14 of the subjects were tested with the XM-76 operated in its normal stabilized mode and 15 were tested with the device caged (nonstabilized). On Flight 3, the two subject groups operated the device in the mode opposite to that used on Flight 2. The results of a t-test evaluation of potential differences in selected group means for the different flight conditions are listed at the bottom.

	Flight 1	Flight 2	Flight 3	Caged Flights	Stabilized Flights
Group Mean	1.69	2.50	2.86	2.4	2.94
Standard Deviction	0.33	0.54	0.50	0.50	0.47
Standard Error of Mean	0.06	0.10	0.09	0.09	0.09

t - test evaluation of differences between selected means

	Flight 1 and Flight 2	Flight 1 and Flight 3	Flight 2 and Flight 3	Caged and Stabilized
t	6.88	10.47	2.62	4.05
Significant Difference Present	Yes	Yes	Yes	Yes
Probability Level	.001	.001	.05	.001

Table II

Summary of flight observer ratings of airsickness symptoms for the subject group under the denoted flight conditions. Scores for the individual subjects were based on separate observations made before and after each flight and immediately following each of the 5 target passes (See pages A-1 and A-2 for symptom rating details). The results of a t-test evaluation of potential differences in selected group means for the different flight conditions are listed at the bottom.

	Flight 1	Flight 2	Flight 3	Caged Flights	Stabilized Flights
Group Means	5.59	24.38	21.96	26.14	20.21
Standard Deviation	5.89	20.59	15.26	20.02	15.54
Standard Error of Mean	1.09	3.82	2.83	3.72	2.89

t - test evaluation of difference between selected means

	Flight 1 and Flight 2	Flight 1 and Flight 3	Flight 2 and Flight 3	Caged and Stabilized
t	4.72	5.39	0.51	1.25
Significant Difference Present	Yes	Yes	No	No
Probability Level	.001	.001	--	--

to those of Flight 2 was also significant, but only to the .05 probability level. It is probable that this improvement reflects a learning or practice effect relative to the usage of the XM-76 device on the two successive flights.

In Table II, a comparable statistical summary is presented of the relative level of the airsickness symptoms of the subject group as judged to be present by the onboard flight observer. These airsickness scores were derived from seven separate flight observer judgments made during the course of a single flight; i.e., one preflight, one following each of the five passes, and one postflight. The symptoms evaluated during the pre- and postflight judgments are shown on Page A-1 of the Appendix; those rated following each pass are shown on Page A-2. Each listed symptom was evaluated on a 1-to-10 scale by the flight observer where 1 denoted that the symptom was not present and 10 indicated that the symptom was present at a maximal level. As a matter of convenience to later analysis, the 1-to-10 scale was linearly transformed to a 0-to-9 scale to arrive at a numerical score for each symptom. Based on this latter scale, a total airsickness score for a given flight was calculated as the sum of the four symptom ratings made preflight, the six symptoms rated postflight, and the 25 symptom ratings made inflight based on five symptom ratings per target pass. The "hand-steadiness" listing shown at the bottom of Page A-1 was not scored on Flight 1 since it applied only to the use of the XM-76 device proper on Flights 2 and 3. To allow the airsickness symptoms to be directly compared for the three different flights, this hand-steadiness measure was not included in the Table II mean data. With this format, the minimal and maximal airsickness levels are numerically defined as 0 and 315, respectively.

As indicated by the group mean data of Table II, the airsickness symptoms manifested by the group on Flight 1 were considerably lower than those displayed on Flights 2 and 3, where the XM-76 viewing device was in use. The t-test data in this table establish that the differences were significant to the .001 level. The group mean data also establish that the airsickness symptoms were slightly lower on Flight 3 as compared to Flight 2. This might be expected in that habituation effects are known to exist that reduce motion sickness symptoms upon repeated exposure to the same stimulus conditions. It should be observed, however, that the difference between the Flight 2 and 3 means was not statistically significant. Comparison of the symptoms manifested under the caged and stabilized viewing modes shows a lower group mean in favor of stabilization. Again, this difference was not statistically significant. In effect, the Table II data indicate that the performance of the assigned observation task with the naked eye causes less stress than with the XM-76 device, whether operated in the stabilized or nonstabilized mode. The Table II flight observer ratings do not, however, give any statistical evidence that the stabilization feature proper of the XM-76 either increases or decreases the airsickness level as compared to the nonstabilized results. In fact, the group mean data slightly favor the stabilization mode.

Table III contains a summary listing of the subjects' personal estimates or ratings of the relative discomfort experienced on each of the five target passes for each of the flight conditions. These data were derived from Item 6 of the postflight questionnaire (Page A-3) which requested the subject to evaluate his discomfort on a 0-to-6 scale.

Table III

Summary of subject self-ratings of discomfort experienced on the 5 target passes as derived from from Item 6 of the post-flight questionairre (See page A-3). Results of the t-test evaluation of potential differences in the group means are listed at the bottom.

	Flight 2	Flight 3	Caged Flights	Stabilized Flights
Group Mean	13.2	7.8	11.1	9.8
Standard Deviation	5.85	5.92	5.95	6.90
Standard Error of Mean	1.09	1.10	1.10	1.28
t - test evaluation of differences between selected means				
	Flight 2 and Flight 3		Caged and Stabilized Flts.	
t	3.50		0.79	
Significant Difference Present	Yes		No	
Probability Level	.01		--	

Table IV

Summary of subject self-ratings of airsickness symptoms experienced on the target pass judged to produce the greatest stress as derived from Item 7 of the post-flight questionairre (See page A-4). Results of the t-test evaluation of potential differences in the group means are listed at the bottom.

	Flight 2	Flight 3	Caged Flights	Stabilized Flights
Group Mean	5.4	4.2	5.1	4.5
Standard Deviation	4.55	5.67	5.48	4.84
Standard Error of Mean	0.85	1.05	1.02	0.90
t - test evaluation of differences between selected means				
	Flight 2 and Flight 3		Caged and Stabilized Flts.	
t	0.87		0.41	
Significant Difference Present	No		No	
Probability Level	--		--	

Accordingly, minimal and maximal discomfort scores are represented by 0 and 6, respectively. The Table III group mean scores for this subjective self-rating indicate less discomfort on Flight 3 as compared to Flight 2. This difference was significant to the .01 level and points toward the previously mentioned habituation effect. The group mean for the stabilized viewing condition was also slightly less than for the caged condition, but not to a statistically significant degree.

Table IV is a listing of a second form of subjective self-rating of personal reactions to the various flight conditions. These group mean data pertain to Item 7 of the post-flight questionnaire which requested each subject to rate seven different symptoms on a 0-to-6 scale for the target pass he considered to produce the greatest stress. Again, the Flight 2 symptoms were slightly less than those of Flight 3. Correspondingly, the self-rating results showed fewer symptoms when the device was stabilized rather than caged. Neither of these differences was statistically significant, however.

In Item 5 of the postflight questionnaire, the subject was asked to check the number of the pass which he thought produced the greatest stress in terms of his own personal reactions. The replies associated with this item are summarized in Table V for each of the flight conditions, with each numerical entry representing the percentage of the total subject group (N = 29) who identified a given pass as the greatest stressor. Surprisingly, the two straight and level passes at the targets (Passes 1 and 5) were consistently identified as producing greater stress than the second pop-up maneuver (Pass 4). The over-all results indicate that the S-turns maneuver (Pass 3) was probably the greatest stressor. The highest rating for this pass resulted when the XM-76 was operated in the stabilized mode.

Further insight into the subjective rating of flight stress is provided by Figure 1 which is a plot of the Table III discomfort data on an individual pass basis. The general trend of these data indicates that the level of discomfort gradually increased as the flight progressed, reaching a plateau on Pass 3 which was maintained through Pass 5. This figure also indicates that the subjective self-rates of discomfort were greater on Flight 2 than on Flight 3 for all five passes, which again points toward an habituation effect. As with the Table III data, the individual pass data show little difference between caged and stabilized operation of the XM-76.

Figure 2 is a similar pass-by-pass breakdown of data from the flight observers' ratings of airsickness as derived from the individual datum used to construct Table II. As with the subjects' self-discomfort ratings, these data indicate a gradual rise in symptom level as the flight progressed. In correspondence to the group mean data of Table II which are based on all five passes plus the pre- and postflight ratings, the individual pass data of Figure 2 show little difference in the magnitude of the symptoms present on Flights 2 and 3. A comparison of the stabilized and caged data of Figure 2, however, shows a trend in favor of stabilization, particularly during the first three passes.

It should be emphasized that the over-all level of the airsickness symptoms observed in the subject group was of relatively low magnitude throughout the course of

Table V

Results of subject checklist selection of the target pass causing the greatest stress as derived from Item 5 of the post-flight questionairre (See page A-3). Listed entries represent the percentage of the subject group who checked the denoted target pass on a given flight as causing the greatest stress in terms of personal reactions or discomfort.

	Flight 2	Flight 3	Caged Flights	Stabilized Flights
Pass 1 - Straight and level flight	27.6	17.2	24.1	20.7
Pass 2 - Pop-up maneuver	10.3	17.2	17.2	10.3
Pass 3 - S turns	31.0	31.0	24.1	37.9
Pass 4 - Pop-up maneuver	0.0	10.3	6.9	3.4
Pass 5 - Straight and level flight	31.0	24.1	27.6	27.6
Total	99.9	99.8	99.9	99.9

Table VI

Listing of Pearson's correlation coefficients and related statistical significance levels for various combinations of the experimental data collected with the XM-76 viewing device operated under stabilized and caged (nonstabilized) conditions.

Correlation Variables		Correlation Coefficients					
		Caged Flights			Stabilized Flights		
Data Set 1	Data Set 2	Corr. r	Sign. Diff.	Prob. Level	Corr. r	Sign Diff.	Prob. Level
Inflight visual acuity scores	Observer rating of airsickness	-.06	no	--	-.37	yes	.05
Inflight visual acuity scores	Subject discomfort on passes	-.23	no	--	-.29	no	--
Inflight visual acuity scores	Subject symptoms on worst pass	.12	no	--	.12	no	--
Observer rating of airsickness	Subject discomfort on passes	.29	no	--	.03	no	--
Observer rating of airsickness	Subject symptoms on worst pass	.55	yes	.01	-.07	no	--
Subject discomfort on passes	Subject symptoms on worst pass	.52	yes	.01	.49	yes	.01

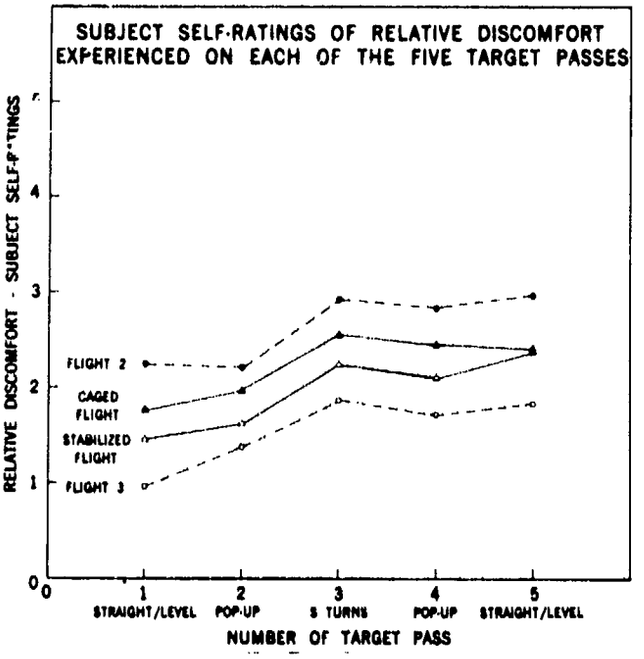

Figure 1

Plot of the mean values of the subject self-ratings of relative discomfort experienced on each of the five sequential passes at the targets. The general trend of the data indicates a gradual rise in discomfort level as the flight progressed, reaching somewhat of a plateau on Pass 3. These data show little difference between the discomfort ratings that resulted when the XM-76 viewing device was operated in its normal stabilized mode and the ratings when operated in its nonstabilized (caged) mode. The lower discomfort level reported on Flight 3 as compared to the level reported on Flight 2 probably signifies the presence of an habituation effect.

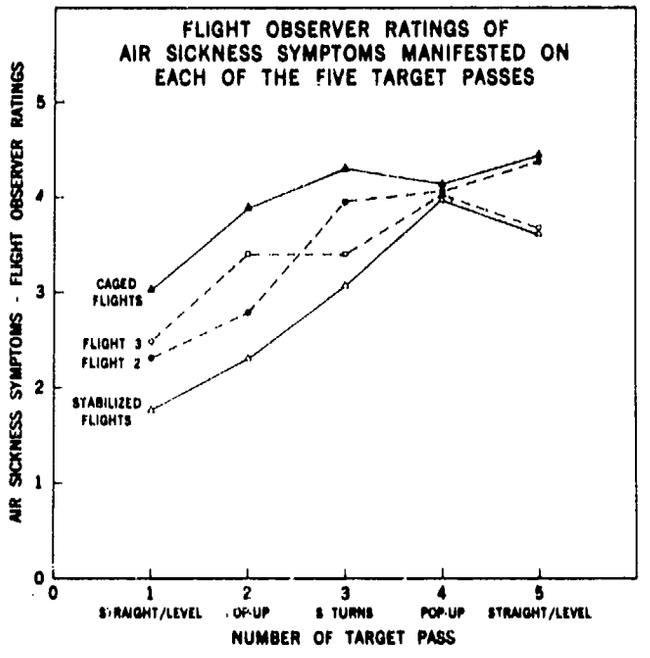

Figure 2

Plot of the mean values of the airsickness symptom levels as scored by the flight observer on each of the five passes at the targets. With this measure, little difference exists between the symptom level present on Flight 2 and the level present on Flight 3. The magnitude of the symptoms present when the observations were made with the stabilized XM-76 was, however, considerably lower than the magnitude present when the observations were made with the caged XM-76. Because of the large variations in the level of the individual symptoms of the subject group, the denoted difference in caged and stabilized symptom level is not statistically significant.

the experiment. For example, based on the motion sickness diagnostic criteria of Graybiel et al. (ref. 28), the flight observer ratings of airsickness level on Flights 2 and 3 would fall into the slight-to-moderate malaise category for the subject group. The symptom level on Flight 1 was obviously of even lower magnitude. As judged by the flight observer, only two of the subjects (S5 and S26) could be considered to be highly susceptible to the stimulus conditions of the experiment. Subject S5 on Flight 2, Pass 4, using the stabilized XM-76, stated it was "easy to get vertigo." On Pass 5 his comments included, "Head spinning -- dizzy -- wow!" The same subject also experienced difficulty when he operated the XM-76 in the nonstabilized mode on Flight 3; on Pass 3, he stated, "This thing is dangerous." His postflight comments about that flight included, "So dizzy I just could not see the targets even though I knew exactly where they were -- I feel all fouled up." Subject S26, on Flight 2, Pass 1, using the nonstabilized XM-76, stated, "This causes me to be nauseous." On Pass 5, he stated, "I have stomach awareness," and was observed to be sweating profusely. Other subjects who made motion sickness-related comments included S18, who stated on Flight 2, Pass 1, using stabilized optics, "This stuff is really bad -- you could get yourself sick doing this." (He later stated that he had experienced slight dizziness during the Pass 3 "S" turn maneuvers.) S11 reported headache symptoms on both the caged and stabilized flights. S21 stated on Flight 2, Pass 4, using caged optics, "Boy, you sure can get vertigo doing this."

Table VI is a listing of Pearson's correlation coefficients that were calculated for a variety of combinations of the individual subject response data collected for the caged and stabilized operating modes of the device. These calculations indicate that the visual acuity scores did not correlate with the flight observer airsickness ratings when the device was caged; a small negative correlation ($r = -.37$) significant to only the .05 level existed when the device was stabilized. No correlation was found between the visual acuity scores and the two self-rating measures that involved relative discomfort on the five passes as well as symptoms experienced on the pass judged to be the greatest stressor. A correlation of .55 significant to the .01 level was found between the flight observer ratings and the subject symptom ratings for the worst pass but only for the caged operating conditions. As would be expected, there was a significant correlation for the two subject self-rating data sets for both operating modes of the XM-76. In general, the correlation data do not support the existence of a strong link between the magnitude of airsickness symptoms manifested by a given subject and his related performance on the assigned observation task.

CONCLUSIONS

To summarize, the airsickness data collected by the onboard flight observer indicate that the selected set of flight maneuvers did not offer any significant discomfort to the subjects while they performed the assigned air-to-ground observation task with the naked eye. However, when the observations were made with the assistance of the viewing device, the level of the airsickness symptoms during the course of the flight rose considerably. Importantly, this rise in symptom magnitude was present whether the device was operated in its normal stabilized mode or in its caged (nonstabilized) mode.

Furthermore, the flight observer ratings of airsickness magnitude did not show any statistically significant difference in symptom level for the two operating modes. In contradistinction to the generally accepted hypothesis that stabilization induces airsickness, the general trend of the data reported here showed a bias in favor of stabilization decreasing the symptom level. Analysis of these same data on a pass-to-pass basis indicated a gradual rise in symptom level for both stabilized and nonstabilized viewing conditions as the flight progressed. Related data derived from the postflight questionnaires issued to the participating subjects also showed no statistically significant difference in discomfort level for the two operating modes of the device. With these data, a fall in discomfort level was noted on Flight 3 as compared to the level noted on Flight 2 (the order of use of the two operating modes of the device was counterbalanced on these two flights), indicating the probable presence of an habituation effect.

In essence, no evidence was found to indicate that the stabilization feature proper of this 7X magnification device is responsible for the airsickness occasionally reported by individuals using such devices in air-to-ground observation. It would appear from the control data of this study that whenever a magnification device (whether stabilized or nonstabilized) is used in a similar airborne environment, airsickness incidence will rise according to the basic airsickness susceptibility of each viewer. Since stabilization of the optical device definitely improves inflight visual acuity, and since the airsickness symptom levels observed in this study were of relatively low magnitude, continued technological development of this class of viewing device for military purposes would appear to be fully warranted. Further support in this direction has been provided by a recent airborne evaluation (ref. 29) of five different stabilization devices, using the same targets as in this study. The participating subjects, all experienced observers, did not report a nausea problem.

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APPENDIX

Flight Data Sheets and Postflight Questionnaires

DATA SHEET: PRE/POST FLIGHT CHECKOUT		
DATE OF FLIGHT	SUBJECT NAME:	FLIGHT NO.
PILOT:	FLT. OBSERVER	
FLT. INSTRUM:	BACKUP OBSERVER:	
TGT. 1 CONTROLLER:	TGT. 2 CONTROLLER	

FLIGHT OBSERVER TO VERIFY THAT SUBJECT EQUIPPED WITH PROPER VIEWING DEVICE	UNAIDED EYE	XM-76 CAGED	XM-76 STABILIZED

PREFLIGHT SUBJECT RATING: Perform immediately after takeoff.

FACIAL PALLOR	1	2	3	4	5	6	7	8	9	10
SWEATING	1	2	3	4	5	6	7	8	9	10
FACIAL EXPRESSION	1	2	3	4	5	6	7	8	9	10

PREFLIGHT ANXIETY	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	9	10

TAKEOFF TIME	LANDING TIME

POSTFLIGHT RATING OF VISIBILITY AND TURBULENCE - Flight Observer to fill in:

FLIGHT VISIBILITY RATING	0 Very Good		0		0		0 Normal		0		0		0 Very Poor
FLIGHT TURBULENCE RATING	0 Very Calm		0		0		0 Normal		0		0		0 Very Rough

POSTFLIGHT SUBJECT RATING: Perform shortly after landing:

FACIAL PALLOR	1	2	3	4	5	6	7	8	9	10
SWEATING	1	2	3	4	5	6	7	8	9	10
FACIAL EXPRESSION	1	2	3	4	5	6	7	8	9	10

POSTFLIGHT ANXIETY	1	2	3	4	5	6	7	8	9	10
SLOW RECOVERY	1	2	3	4	5	6	7	8	9	10
OVERALL RATING	1	2	3	4	5	6	7	8	9	10

SUMMARY COMMENTS ON FLIGHT: List any difficulties in flight protocol, target difficulties; subject comments, et cetera.

INFLIGHT DATA SHEET

SUBJECT NAME:	FLIGHT NO.	PASS NO.

RANGES AT WHICH FLT. OBSERVER TO REQUEST RESPONSE DATA FROM SUBJECT		CAN SUBJECT LOCATE AIRFIELD NAKED EYE	CAN SUBJECT LOCATE AIRFIELD XM-76	CAN SUBJECT LOCATE TARGET BOARDS XM-76	CAN SUBJECT IDENTIFY BLACK CONTRAST ON ANY OF THE TARGETS - IF YES WRITE-IN RANGE WHERE DETECTED			SUBJECT ESTIMATE OF TARGET SETTING. Request Forced-Choice Judgments within Each Range Bracket - Enter Exact Range in Space Provided.					
		IF YES WRITE IN RANGE	IF YES WRITE IN RANGE	IF YES WRITE IN RANGE	TARGET 1	TARGET 2	TARGET 3	TARGET 1		TARGET 2		TARGET 3	
DRO.	M							TGT.	RNGE	TGT.	RNGE	TGT.	RNGE
168	8000												
157	7500												
147	7000												
136	6500												
126	6000												
115	5500												
105	5000												
94	4500												
84	4000												
73	3500												
63	3000												
52	2500												
42	2000												
31	1500												
21	1000												

AT END OF EACH PASS, FLT. OBSERVER TO VIEW TARGETS AND ENTER ORIENTATION IN SPACES PROVIDED AT RIGHT.			

SUBJECT RESPONSE RATING: Complete at end of each pass at target.

FACIAL PALLOR	1 2 3 4 5 6 7 8 9 10	INFLIGHT ANXIETY	1 2 3 4 5 6 7 8 9 10
SWEATING	1 2 3 4 5 6 7 8 9 10	HAND STEADINESS (DEVICE)	1 2 3 4 5 6 7 8 9 10
FACIAL EXPRESSION	1 2 3 4 5 6 7 8 9 10	OVERALL RATING	1 2 3 4 5 6 7 8 9 10

COMMENTS:

POSTFLIGHT DEBRIEFING QUESTIONNAIRE		Sheet 1
NAME:	FLIGHT	DATE:

The following questions deal with the flight you have just completed. Based on your own personal judgment, check the appropriate entry on the rating scale provided for each of the following questions.

1. RATE THE ATMOSPHERIC VISIBILITY CONDITIONS FOR THIS SPECIFIC FLIGHT.

0	0	0	0	0	0	0
VERY POOR			NORMAL DAY			VERY GOOD

2. RATE THE AIR TURBULENCE CONDITIONS FOR THIS SPECIFIC FLIGHT.

0	0	0	0	0	0	0
VERY ROUGH			NORMAL AIR			VERY CALM

3. COMPARED TO THE NAKED EYE, WHAT EFFECT DID THE VIEWING DEVICE HAVE ON YOUR ABILITY TO LOCATE THE TARGETS?

0	0	0	0	0	0	0
GREATLY DEGRADED			NO EFFECT			GREATLY IMPROVED

4. COMPARED TO THE NAKED EYE, WHAT EFFECT DID THE VIEWING DEVICE HAVE ON YOUR ABILITY TO DISTINGUISH TARGET DETAIL ONCE THE TARGET WAS LOCATED?

0	0	0	0	0	0	0
GREATLY DEGRADED			NO EFFECT			GREATLY IMPROVED

5. OF THE FIVE PASSES YOU MADE AT THE TARGETS, CHECK THE ONE PASS WHICH PRODUCED THE GREATEST STRESS IN TERMS OF YOUR OWN PERSONAL REACTIONS OR DISCOMFORT.

0	0	0	0	0
PASS 1	PASS 2	PASS 3	PASS 4	PASS 5

6. IN THE SPACES PROVIDED BELOW, RATE EACH INDIVIDUAL PASS AT THE TARGET ACCORDING TO YOUR OWN PERSONAL REACTIONS OR DISCOMFORT IMMEDIATELY FOLLOWING COMPLETION OF THE DENOTED PASS:

PASS 1

0	0	0	0	0	0	0
NO DISCOMFORT						STRONG DISCOMFORT

PASS 2

0	0	0	0	0	0	0
NO DISCOMFORT						STRONG DISCOMFORT

PASS 3

0	0	0	0	0	0	0
NO DISCOMFORT						STRONG DISCOMFORT

PASS 4

0	0	0	0	0	0	0
NO DISCOMFORT						STRONG DISCOMFORT

PASS 5

0	0	0	0	0	0	0
NO DISCOMFORT						STRONG DISCOMFORT

POSTFLIGHT DEBRIEFING QUESTIONNAIRE								Sheet 2
7. WITH REFERENCE TO THE PASS NUMBER YOU IDENTIFIED IN QUESTION NO. 5, RATE YOUR OWN REACTIONS RELATIVE TO THE ITEMS LISTED BELOW:								
STOMACH AWARENESS RATING								
NO STOMACH AWARENESS	0	0	0	0	0	0	0	STRONG STOMACH AWARENESS
DIZZINESS RATING								
NO DIZZINESS	0	0	0	0	0	0	0	STRONG DIZZINESS
OVER-ALL SICKNESS RATING								
NO SICKNESS EFFECTS	0	0	0	0	0	0	0	STRONG SICKNESS EFFECTS
HOT FEELING SENSATION								
DID NOT EXPERIENCE	0	0	0	0	0	0	0	HOT FEELING
COLD FEELING SENSATION								
DID NOT EXPERIENCE	0	0	0	0	0	0	0	COLD FEELING
DRY FEELING SENSATION								
DID NOT EXPERIENCE	0	0	0	0	0	0	0	DRY FEELING
WET FEELING SENSATION								
DID NOT EXPERIENCE	0	0	0	0	0	0	0	WET FEELING
COMMENTS								
Enter any comments you wish concerning the over-all flight, the individual passes at the target, or the viewing device itself:								

POSTFLIGHT DEBRIEFING QUESTIONNAIRE	
NAME:	DATE

The following questions involve a comparison of the viewing device you used today with the viewing device used on the previous flight. Check appropriate entries.

1. ATMOSPHERIC VISIBILITY TODAY AS COMPARED TO PREVIOUS FLIGHT.

MUCH WORSE TODAY			ABOUT THE SAME			MUCH BETTER TODAY
0	0	0	0	0	0	0

2. AIR TURBULENCE CONDITIONS TODAY AS COMPARED TO PREVIOUS FLIGHT.

MUCH WORSE TODAY			ABOUT THE SAME			MUCH BETTER TODAY
0	0	0	0	0	0	0

3. HOW WOULD YOU RATE THE VIEWING DEVICE YOU USED TODAY COMPARED WITH THE PREVIOUS DEVICE IN TERMS OF IMPROVING YOUR ABILITY TO INITIALLY LOCATE THE TARGETS?

TODAY'S DEVICE MUCH WORSE			ABOUT THE SAME			TODAY'S DEVICE MUCH BETTER
0	0	0	0	0	0	0

4. HOW WOULD YOU RATE THE VIEWING DEVICE YOU USED TODAY COMPARED WITH THE PREVIOUS DEVICE IN TERMS OF IMPROVING YOUR ABILITY TO DISTINGUISH TARGET DETAIL?

TODAY'S DEVICE MUCH WORSE			ABOUT THE SAME			TODAY'S DEVICE MUCH BETTER
0	0	0	0	0	0	0

5. RATE YOUR OVER-ALL PERSONAL REACTIONS TO THIS FLIGHT IN COMPARISON TO YOUR PERSONAL REACTIONS ON THE PREVIOUS FLIGHT.

MUCH STRONGER AWARENESS ON PREVIOUS FLIGHT	STOMACH AWARENESS RATING						MUCH STRONGER AWARENESS TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH MORE DIZZINESS ON PREVIOUS FLIGHT	DIZZINESS RATING						MUCH MORE DIZZINESS TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH STRONGER SICKNESS EFFECTS ON PREVIOUS FLIGHT	OVER-ALL SICKNESS RATING						MUCH STRONGER SICKNESS EFFECTS TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH STRONGER SENSATION ON PREVIOUS FLIGHT	HOT FEELING SENSATION						MUCH STRONGER SENSATION TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH STRONGER SENSATION ON PREVIOUS FLIGHT	COLD FEELING SENSATION						MUCH STRONGER SENSATION TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH STRONGER SENSATION ON PREVIOUS FLIGHT	DRY FEELING SENSATION						MUCH STRONGER SENSATION TODAY
0	0	0	0	0	0	0	
			SAME				
MUCH STRONGER SENSATION ON PREVIOUS FLIGHT	WET FEELING SENSATION						MUCH STRONGER SENSATION TODAY
0	0	0	0	0	0	0	
			SAME				

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Investigators at the Naval Aerospace Medical Research Laboratory and the U. S. Army Aeromedical Research Laboratory conducted a combined field and laboratory study to evaluate observer performance while using an improved XM-76 stabilized viewing device. Air-to-ground observations were made in a UH-1 aircraft, flying maneuvers modeled in part after a scout helicopter scenario. The experimental protocol was such that visual acuity data were collected under three different observation conditions: with the naked eye, with XM-76 operated in its normal stabilized mode, and with the XM-76 operated in a caged or

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nonstabilized mode. Measures of selected airsickness symptoms were derived from an onboard flight observer and from postflight questionnaires. The resulting data indicate that the level of airsickness symptoms manifested by the subject group while using the device was higher than the baseline level present when the observations were made without the device. This rise in symptom level was found to be present whether the XM-76 optics were stabilized or nonstabilized. Importantly, no statistically significant difference could be found between the magnitude of the symptoms present when the device was stabilized and the magnitude when caged. In contradistinction to the hypothesis that the stabilization feature of such devices increases the airsickness potential, the general trend of the data showed the opposite effect. A previous report detailed the results of the visual acuity aspects of the project. The present report pertains primarily to the inflight measures of airsickness potential. A third report will describe the results of the laboratory evaluation of airsickness susceptibility of the individual subjects.